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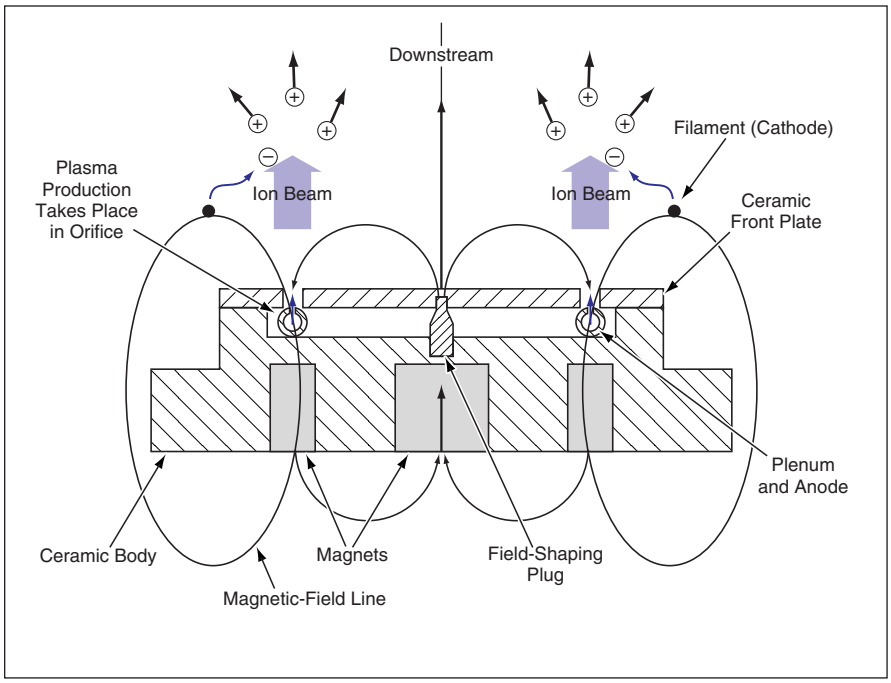


This **Partially Schematic Cross Section** illustrates the design and the principle of operation of the compact plasma accelerator. The device is symmetrical about the z axis.

partly on the basis of the depth of the channels, is of the order of 0.05 mm^3.

The source of electrons is an annular hot filament. This source is located such that emitted electrons must diffuse across the magnetic field to reach the anode. The transverse component of the magnetic field tends to increase the cathode fall voltage. The increase in the cathode fall voltage is necessary for producing energetic electrons for ionization inside the channels. Energetic electrons that have sufficient velocity components parallel to the magnetic field enter the channels to participate in the ionization process. Those without sufficient parallel velocities are reflected by the magnetic-mirror force (a consequence of the chosen magnetic-field configuration and strength). Because the electrons reflected by the mirror force are constrained by the magnetic-field lines, the reflected electrons oscillate between the filament and the plenum. The likelihood that these electrons will ionize neutral atoms in the plenum region increases as this oscillation continues.

Ions formed in the channels are accelerated by the electrostatic-potential gradient across the plasma sheath at the plenum. The ions emitted from the sheath at the anode plenum form an axially directed beam. The ion beam is neutralized by electrons emitted into the beam by the filament. In this respect, the filament provides not only the ionizing electrons but also the neutralizing electrons.

It should be pointed out that the choice of the electron source used in this device is quite general. In the prototype, a coated filament was used. The basic concept of this compact plasma accelerator (CPA) is also compatible with a field-emitter-array cathode. The appeal of the field-emitter approach lies in a higher current density and greater simplicity of integration (no filament heater supply is necessary).

A prototype of this CPA generated a monoenergetic (80-eV) ion beam of 30-mA current at a discharge power of approximately 40 W. The propellant efficiency at this condition was calculated to be approximately 88 percent. The peak ion current densities of the beamlets formed in the prototype CPA were similar to those measured in gridded ion thrusters of much higher power (e.g., 2.3 kW).

This work was done by John E. Foster of **Glenn Research Center**. *Further information is contained in a TSP (see page 1).*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17230.

Improved Electrohydraulic Linear Actuators

Advantages include better position control and end-of-stroke buffering.

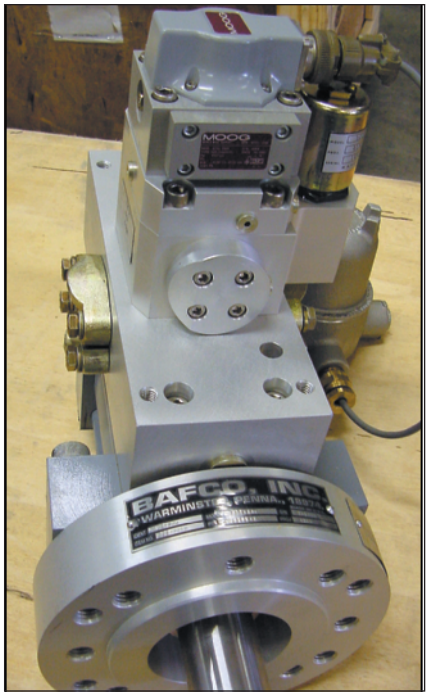
Stennis Space Center, Mississippi

A product line of improved electrohydraulic linear actuators has been developed. These actuators are designed especially for use in actuating valves in rocket-engine test facilities. They are also adaptable to many industrial uses, such as steam turbines, process control valves, dampers, motion control, etc.

The advantageous features of the improved electrohydraulic linear actuators are best described with respect to shortcomings of prior electrohydraulic linear actuators that the improved ones are intended to supplant. The shortcomings are the following:

- They perform unreliably and inconsistently as positioning devices.
- Their capabilities for end-of-stroke buffering (that is, deceleration to gentle stops at designated stopping positions) range from unsatisfactory to nonexistent, with consequent potential for inducing catastrophic failures.
- It takes long times to manufacture special actuators to meet specifications, and the costs of such actuators are high.

The figure depicts one of the improved actuators. The flow of hydraulic fluid to the two ports of the actuator cylinder is controlled by a servo valve that is controlled by a signal from a servo amplifier that, in turn, receives an analog position-command signal (a current having a value between 4 and 20 mA) from a supervisory control system of the facility. As the position command changes, the servo valve shifts, causing a greater flow of hydraulic fluid to one side of the cylinder and thereby causing the actuator piston to move to extend or retract a piston rod from the actuator body. A linear variable differential transformer (LVDT) directly linked to the piston provides a



This **Electrohydraulic Linear Actuator** incorporates several improvements over prior commercially available devices of a similar nature.

position-feedback signal, which is compared with the position-command signal in the servo amplifier. When the position-feedback and position-command signals match, the servo valve moves to its null position, in which it holds the actuator piston at a steady position.

The actuator includes a deceleration feature for both extremes of the piston stroke. When the actuator is used to open and close a valve, the deceleration feature prevents damage to valve seats and other components during cycles of rapid stroking. Because the resolution of the LVDT is, for practical purposes, unlimited, the position feedback from the LVDT acts, in conjunction with the deceleration feature, to afford maximum protection against damage in those ranges of position in which protection is most needed. Other advantageous features of the improved actuators are the following:

- To eliminate leaks associated with common tubing connections, the components within the actuator that must be connected to high-pressure hydraulic fluid are connected via a manifold.
- The time and cost of manufacturing are less than those of the prior actuators.
- Optionally, fail-safe valves of a type used widely in the petrochemical industry can be incorporated into the actuators.

This work was done by James Hamtil of BAFCO, Inc., for **Stennis Space Center**.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

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Refer to SSC-00165, volume and number of this NASA Tech Briefs *issue, and the page number.*

A Software Architecture for Semiautonomous Robot Control

Lyndon B. Johnson Space Center, Houston, Texas

A software architecture has been developed to increase the safety and effectiveness with which tasks are performed by robots that are capable of functioning autonomously but sometimes are operated under control by humans. The control system of such a robot designed according to a prior software architecture has no way of taking account of how the environment has changed or what parts of a task were performed during an interval of control by a human, so that errors can occur (and, hence, safety and effectiveness jeopardized) when the human relinquishes control. The present architecture incorporates the control, task-planning, and sensor-based-monitoring features of typical prior autonomous-robot software architectures, plus features for updating information on the environment and planning of tasks during control by a human operator in order to enable the robot to track the actions taken by the operator and to be ready to resume autonomous operation with minimal error. The present architecture also provides a user interface that presents, to the operator, a variety of information on the internal state of the robot and the status of the task.

This work was done by David Kortenkamp of Metrica, Inc., for **Johnson Space Center**. *Further information is contained in a TSP (see page 1).*
MSC-23053